Simplifying Lead Wire Interchanges

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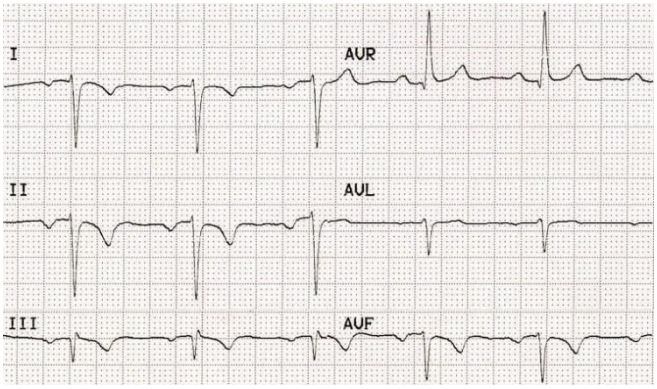
Are you pretty good at diagnosing lead wire interchanges? How about this one…

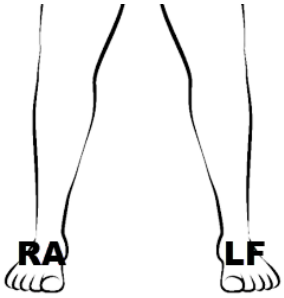


Do you recognize it? A lot of healthcare providers can usually spot a LA/RA lead wire interchange based on the inverted deflections in Lead I but still struggle with the others. I'm going to fix that!

There are six possible lead wire interchanges among all the limb leads, including the neutral wire attached to the right foot. There is no real reason for the neutral wire to be placed on the right foot. One would obtain the same result if it were attached to the patient's forehead.

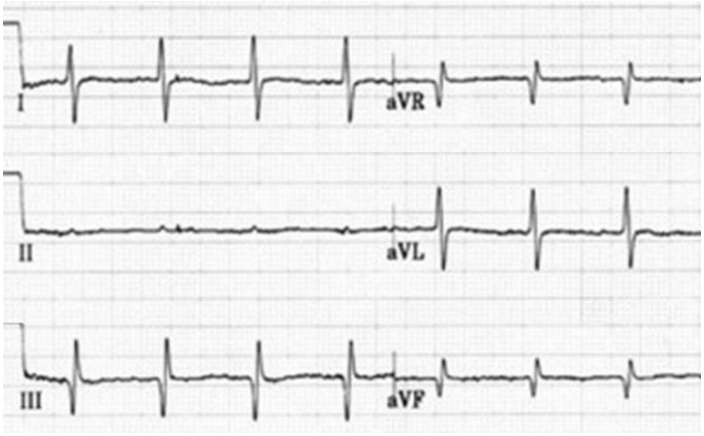
I will begin with the interchanges involving the neutral wire on the right foot. I want to address those first since they are *very easy to recognize*. Just remember: we aren't going to be concerned with where the neutral wire ends up – we are only going to be concerned with the lead wires that are placed on the right and left feet.

First Interchange: RF (neutral) and RA (aVR) Lead Wire Interchange



The RA wire (Lead aVR) is placed on the right foot electrode and the LF electrode with the wire for Lead aVF is on the left foot, its normal location. Remember: the *right leg* and *left leg* should be considered as the *same extremity*. If you place two electrodes adjacent to each other on the same extremity there would be essentially no difference in electrical charge between them. And that's what happens when you have two *recording* electrodes on the right and left feet – they record a near ZERO DIFFERENCE in electrical charge.

Lead II is the difference between the RA electrode (aVR) and the LF electrode (aVF) – but since the RA wire is now attached to the right foot, Lead II will have ZERO VOLTAGE! That means there will be a near-isoelectric line in Lead II.

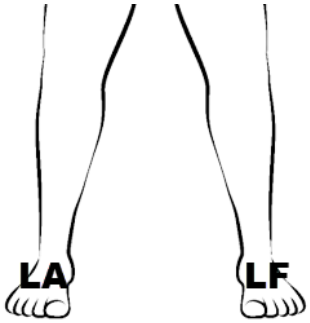


As you can see, when Lead II finds itself measuring from the right foot (RF) to the left foot (LF), there is ZERO VOLTAGE. And this results in a nearly-flat line in Lead II.

About the only other thing that would do this is a disconnected lead wire.

This is very easy to recognize and now you know the diagnosis, so let's move on.

Second Interchange: RF (neutral) and LA (aVL) Lead Wire Interchange



Now we have the left arm (LA) wire attached to the right foot electrode. Keep in mind that the electrodes themselves are not the problem. It's the lead wires being attached to the wrong electrode that is causing this issue!

Now when we record the difference between the LF and LA we again end up with ZERO VOLTAGE. And which lead is the difference in voltage between the LF and LA? It's Lead III. And now, Lead III has minimal recorded voltage difference. What will that look like on the ECG?

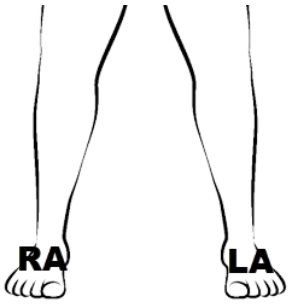
And there you have it! A near isoelectric line in Lead III.

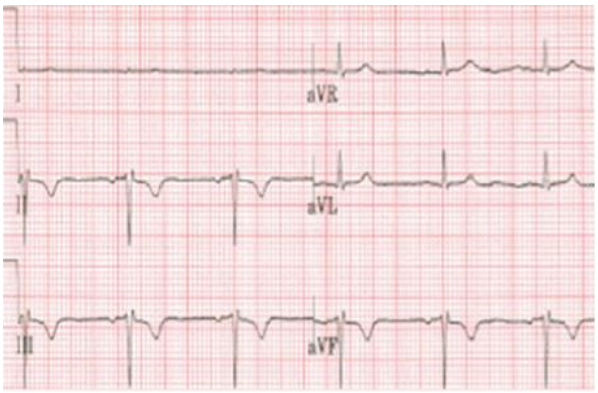
OK… we've seen how Lead II becomes a near-isoelectric line and also how Lead III becomes the same.

We know that Lead II is the difference between the RA and LF electrodes and that Lead III is the difference between the LA and LF electrodes. But how do we end up with a near-isoelectric line in Lead I? Note that both Leads II and III use the LF electrode wire in their calculation; but Lead I doesn't! Lead I is the difference between the LA electrode and the RA electrode. So how do we get the RA and LA wires on the right foot and left foot (respectively)?

Third Interchange: RA and RF (neutral) and LA and LF *DOUBLE* Lead Wire Interchange

This requires a DOUBLE interchange: the RA changes with the RF *and* the LA changes with the LF. Now we have the RA on the right foot and the LA on the left foot. They record a ZERO VOLTAGE in Lead I and Lead I develops a near-isoelectric baseline. This is very rare but it does happen!





But be careful… *advanced emphysema* can also produce a Lead I that looks a lot like this due to the shifting of the mean QRS axis into the horizontal plane (but it's usually accompanied by very tall P waves in the inferior leads).

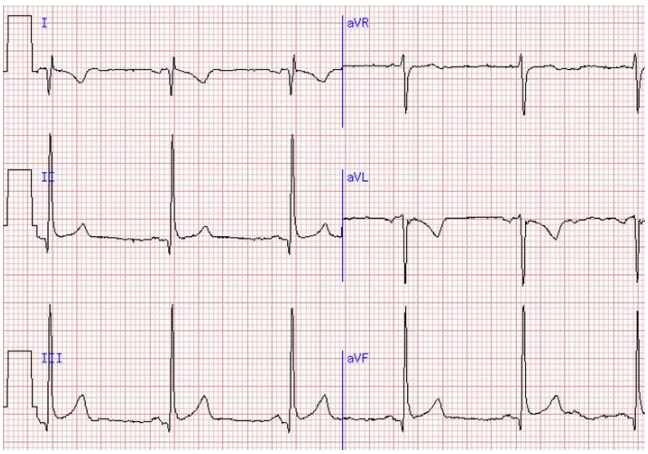
Now let's look at the interchanges in which we use the JONES method…

There will be leads switching places with other leads but again, nothing for you to memorize or be concerned. Just remember one fact: standard leads (I, II, III) can only switch places with other standard leads. Augmented leads (aVR, aVL, aVF) can only switch places with other augmented leads. Lead aVL cannot switch places with Lead II, for instance. This fact benefits YOU because when a lead changes places with another lead, there will be only TWO places for you to look – and you will know those places immediately! Now back to the JONES method…

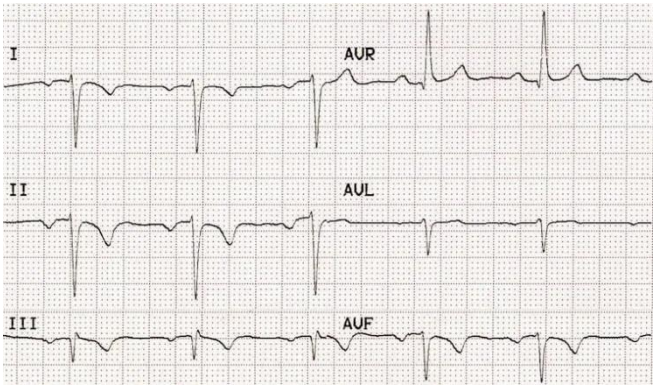
We've reviewed the three lead wire interchanges involving the RF (neutral) wire. Now there are just three lead wire interchanges remaining.

The Jones method begins the moment you pick up the ECG and begin deciding which rhythm is present. There are two leads you will scrutinize very carefully: **Leads I and II**. If the P wave in Lead I is upright, that means atrial depolarization is traveling from right to left – and that's normal! You will also look closely at Lead II for two reasons. An upright P wave means that the P vector is traveling toward the positive pole of Lead II located at +60°. That is very suggestive of an impulse coming from the vicinity of the SA node. But there is one more characteristic in Lead II that you want to see: ***during sinus rhythm Lead II will almost always have the largest P wave of all the limb leads***. And that is where the JONES method begins. If, while determining the rhythm, you notice that Lead II does *not* have the largest P wave but lead I has the largest P wave, then you have diagnosed a *lead wire interchange*. A quick look at Lead aVR to ascertain that Lead aVR is in its correct location will then tell you that this is a **LA/LF lead wire interchange** – probably the most difficult lead wire interchange to diagnose. There are a number of papers that can provide you with the trigonometric calculations that explain why this is so… but you will do just as well by skipping them (if you still want to look further, I have listed them in the references for this article).

The remaining two lead wire interchanges are diagnosed simply by looking at Lead aVR. Why Lead aVR? Because both of the remaining lead wire interchanges involve Lead aVR. Consequently, Lead aVR will always be "out of place" with the two remaining lead wire interchanges.



If you find Lead aVR (RA) in the space for Lead aVL (LA), then Lead aVR has switched places with Lead aVL and there is a LA/RA lead wire interchange (**aVL = LA** and **aVR = RA**). This is a LA/RA lead wire interchange on the left.



If Lead aVR (RA) is located in the space for Lead aVF (LF), then Lead aVR has switched with Lead aVF and there is a RA/LF lead wire interchange (**aVR = RA** and **aVF = LF**). Remember that ECG snippet at the beginning of this article? Look at it again (left)…

You may have thought this was a LA/RA lead wire switch based on the negative deflections in Lead I… but you would have been wrong! Had you used the JONES method, you would not have made that mistake! Instead, you would have found Lead aVR in the space for Lead aVF indicating a RA/LF lead wire interchange. With the JONES method, there is no need to scrutinize the other leads for inverted deflections.

In fact, ALL the standard leads (I, II and III) look like Lead aVR – but they cannot be Lead aVR! Why? ***Because augmented leads (aVR, aVL, aVF) cannot switch with any of the standard leads (I, II, III). Standard leads can only switch with other standard leads and augmented leads can only switch with other augmented leads***.

So, in summary…

1. You learned how to recognize the three lead wire interchanges involving the neutral wire on the right foot. It has nothing to do with the JONES method *which only involves the recording electrodes*, but these interchanges are *very obvious* and *very simple to recognize*.

2. You used the JONES method with the remaining three lead wire interchanges using only Leads II and aVR. One interchange involved the LA and LF and is diagnosed by recognizing that the largest P wave is in Lead I – not in Lead II where it *should* be located. The remaining two lead wire interchanges involved Lead aVR, so all you had to do was locate Lead aVR knowing that there were only two possible places it could be (aVL or aVF).

If Lead aVR was found in the space for aVL, then aVR and aVL switched places which is the same as the RA and LA switching places. On the other hand, if Lead aVR was found in the space for aVF, then aVR and aVF switched places which is the same as RA and LF foot switching places.

There's nothing to memorize.